Trough Technology
Heat Collector Element (HCE)
Solar Selective Absorbers

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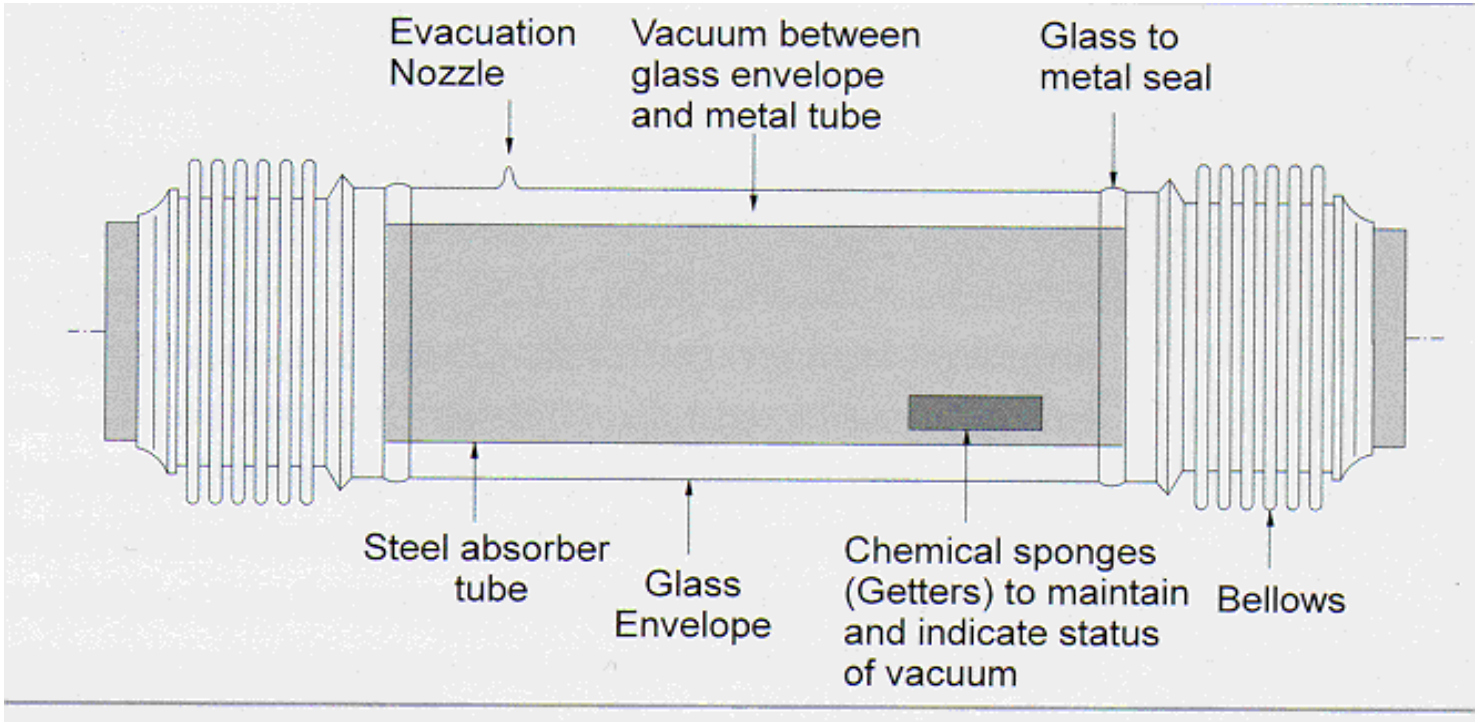
Trough Workshop ASES 2000

Typical Evacuated Heat Collector Element (HCE)



HCE (Receiver) Reliability

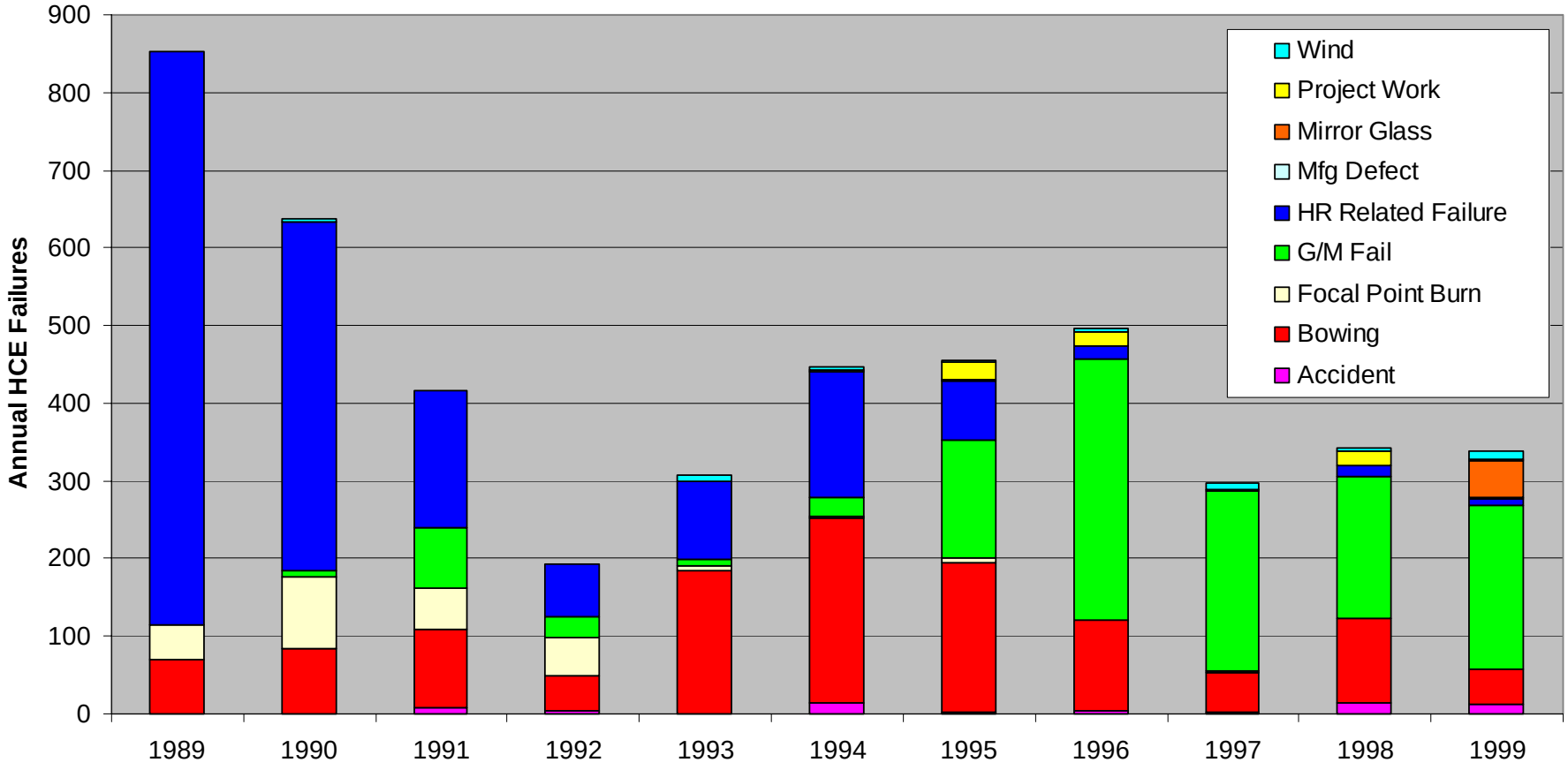
Background

HCE (Receiver) failure / degradation is the single largest cost factor [both performance and O&M] for current & future plants

- **30-40% failure at SEGS VI-IX (9 to 11 years of operation)**
- **loss of vacuum (glass-to-metal seal or other), solar selective coating degradation in air, broken glass**
- **Replacement cost is ~$1000 / HCE (evacuated)**
- **Annual O&M cost is 0.5 ¢/kWh (Cost/Perf)**

HCE (Receiver) Reliability - MWE Study

SEGS VI LS-2 Failures by Cause



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National Renewable Energy Laboratory, Golden CO

Total # HCE (LS-2) Failures: ~4720

SEGS 8 & 9 Harper Lake HCE "Fluorescent" Tubes

-Vacuum Challenged

Glass-to-metal seal failures

Causes:

- **Flux Induced Thermal Stress (increased in winter)**
- **Hydrogen Removal Tube**
- **Vibration**

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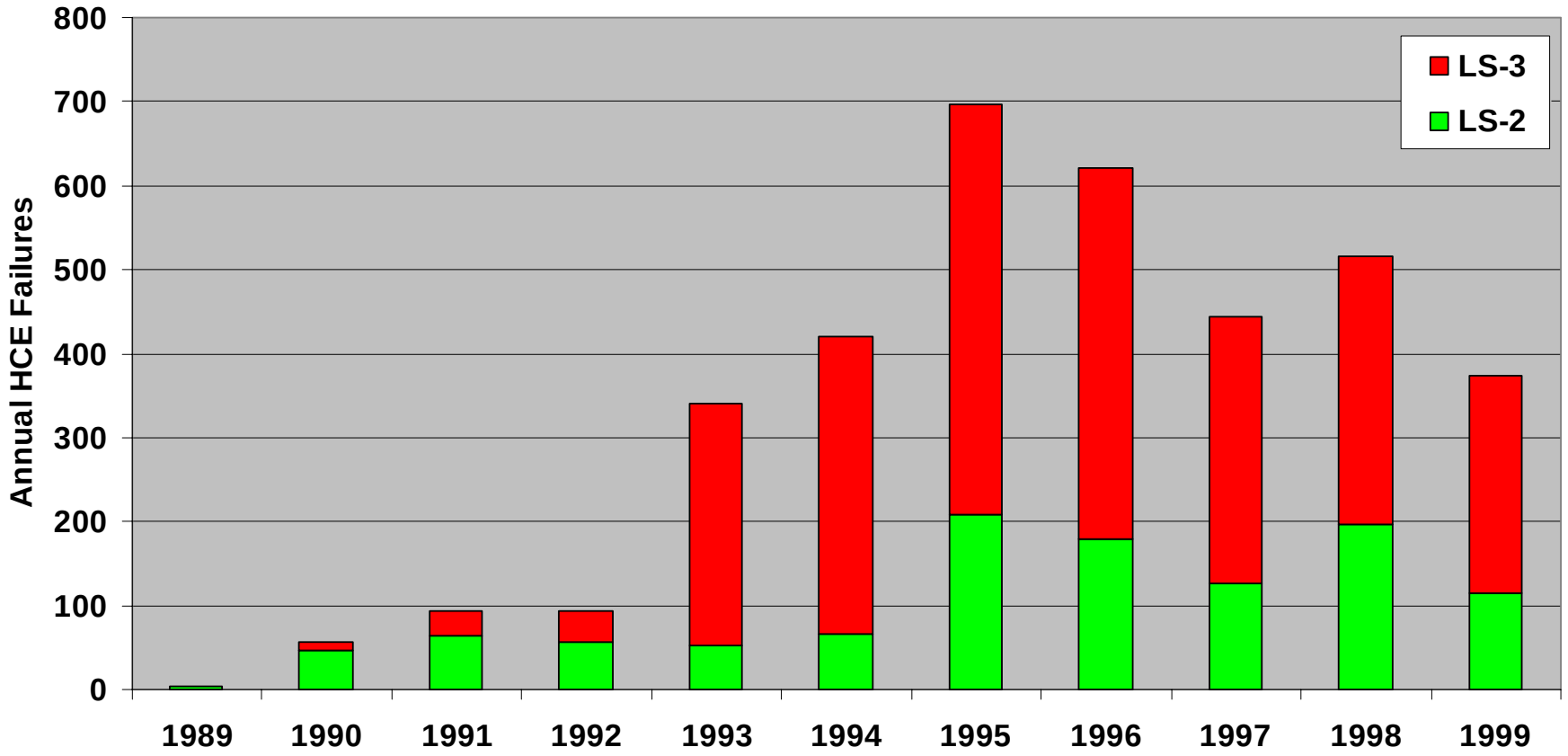
HCE (Receiver) Reliability - MWE Study

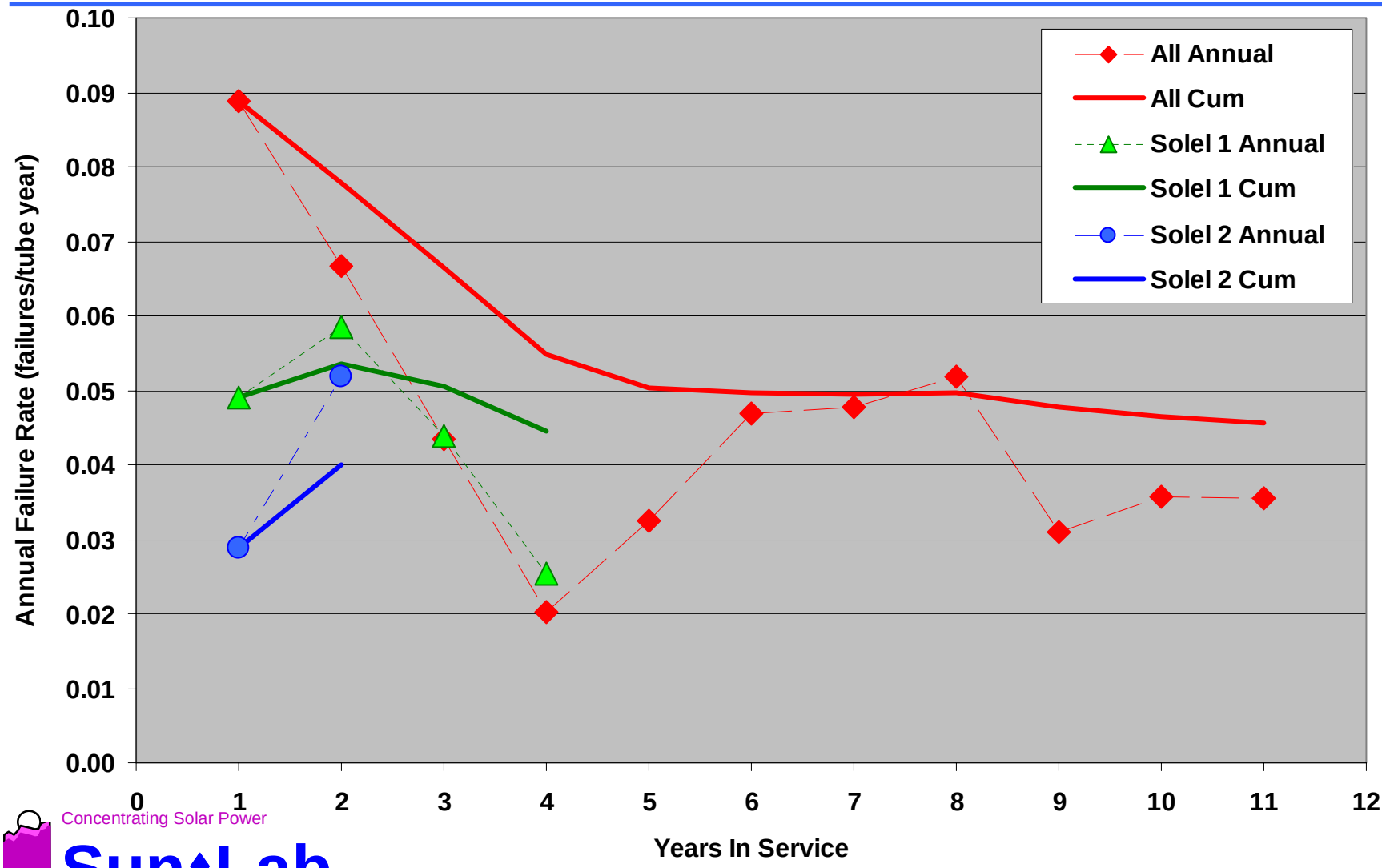
SEGS VII Failures by SCA Type



Total # HCE (LS-2,3) Failures: ~3650

HCE (Receiver) Reliability - MWE Study

SEGS VI - HCE Glass Breakage Failure Rate



HCE (Receiver) Reliability

For improved HCE (receiver) reliability technology must address:

- **Reducing failures of glass-to-metal seals**
  installation: flux and thermal protection ...
- **Improving (significantly) air stability of solar selective coating**

HCE (Receiver) Reliability Approach

Purchase and Test new Solel UVAC Receiver

Solel Claims:

- Improved glass-to-metal seal
- Improved Air-stable cermet selective coating

  Solar Absorptance 97% vs. 95.5%

  Thermal Emittance @ 400C : 0.075 vs. 0.18
- Cleanable and improved anti-reflection (AR) coating on glass envelope

  Solar Transmittance 97% vs. 96%

HCE (Receiver) Reliability Approach

In Field

SEGS O&M Company Testing and Support Task Ordering Agreement (TOA)

- Performance test (LS-2 test loop)
- Three year reliability monitoring (LS-2 & LS-3 collectors)
- Periodic optical properties assessment, thermal imaging
- Accelerate in-air stability evaluation (hottest locations, remove glass, breach vacuum)

HCE (Receiver) Reliability Approach

In Laboratory

- Optical Properties Characterization
- Accelerated Thermal Aging various Temps
- Surface Analysis
- Glass-to-metal seal evaluation

HCE (Receiver) Reliability Status

- **SEGS Test & Support Task Ordering Agreement**
  - **KJCOC TOA In Place**
  - **FPL Energy (In Place ?)**
- **RFP for Solel UVAC Receiver Task Order sent to KJCOC**
  - **Purchase 350 tubes**
  - **Expect field install to begin early FY01**
  - **Expect approximately 40% cost share (half from Solel and half from KJCOC)**

Retrofit Low Cost HCE (Receiver)

KJCOC Concept

Using existing cermet tubing

- **Replace glass envelope and re-evacuate**
  - **glass-to-metal seal with adhesive - ongoing**
  - **SunLab support late FY00 - contract support**

- **Significant technical challenge**
  - **Expect initial limited success with this approach**

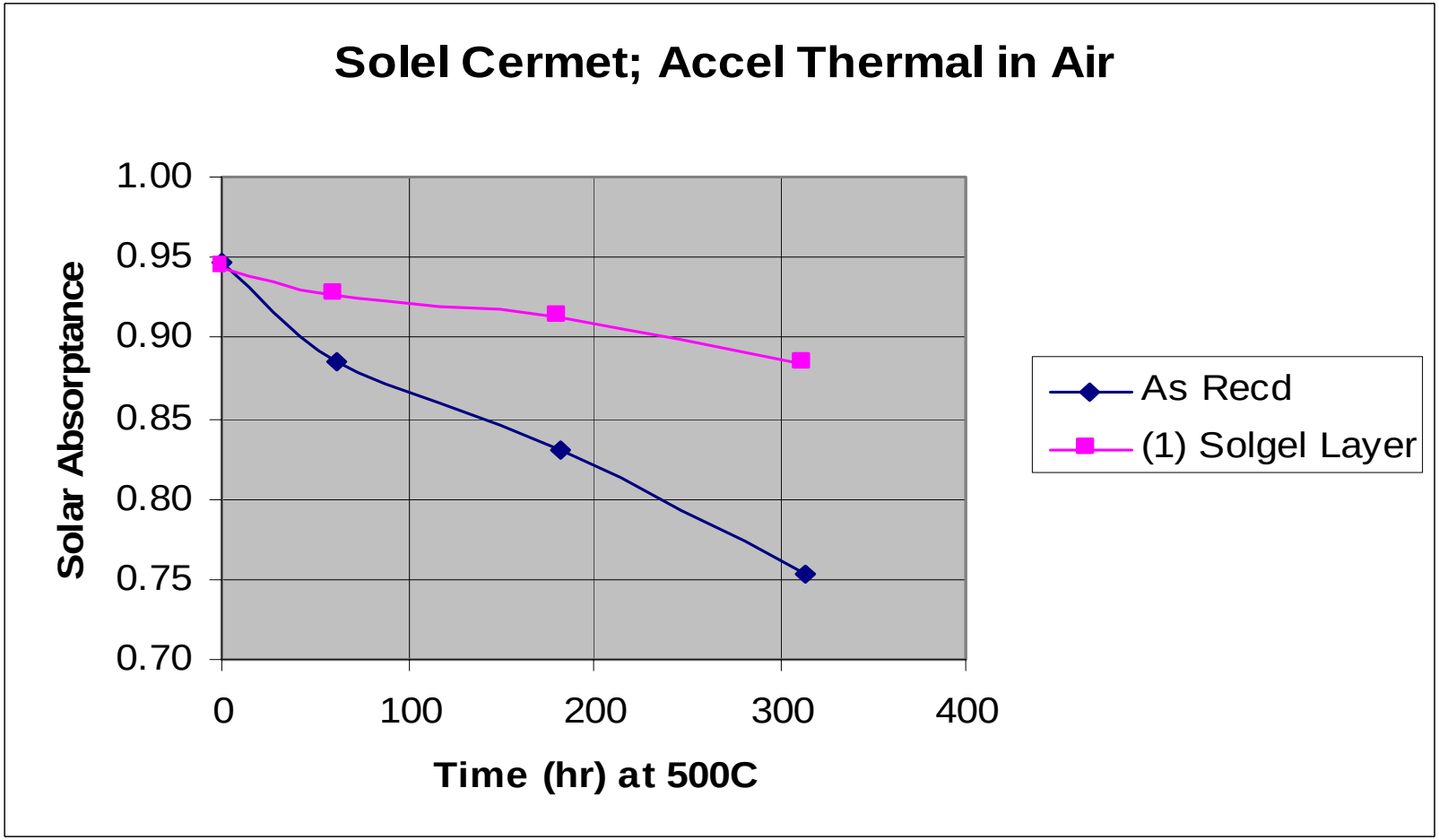
Retrofit Low Cost HCE (Receiver)

SunLab Alternative Approach

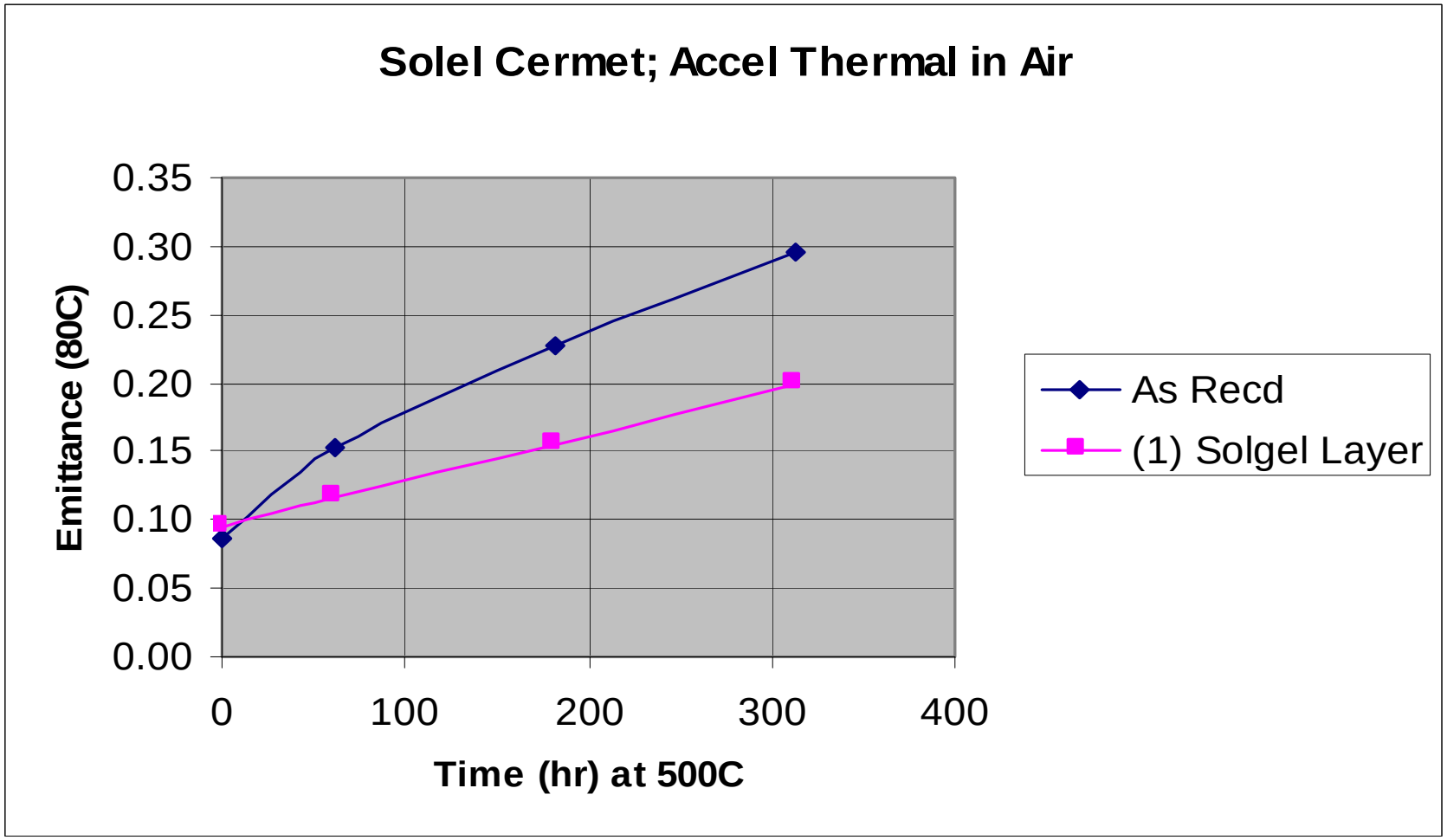
Using existing cermet tubing

- Apply protective (oxidation) coating over cermet
- Accelerate thermal aging (in air)
- Results promising

Selective Absorber - Cermet



Selective Absorber - Cermet



Retrofit Low Cost HCE (Receiver)

SunLab Alternative Approach

Using existing cermet tubing

- **Both KJCOC and Harper Lake very interested**

  100s of "good" cermet tubes available

  Harper: on-site assembly of glass envelope (plus …)

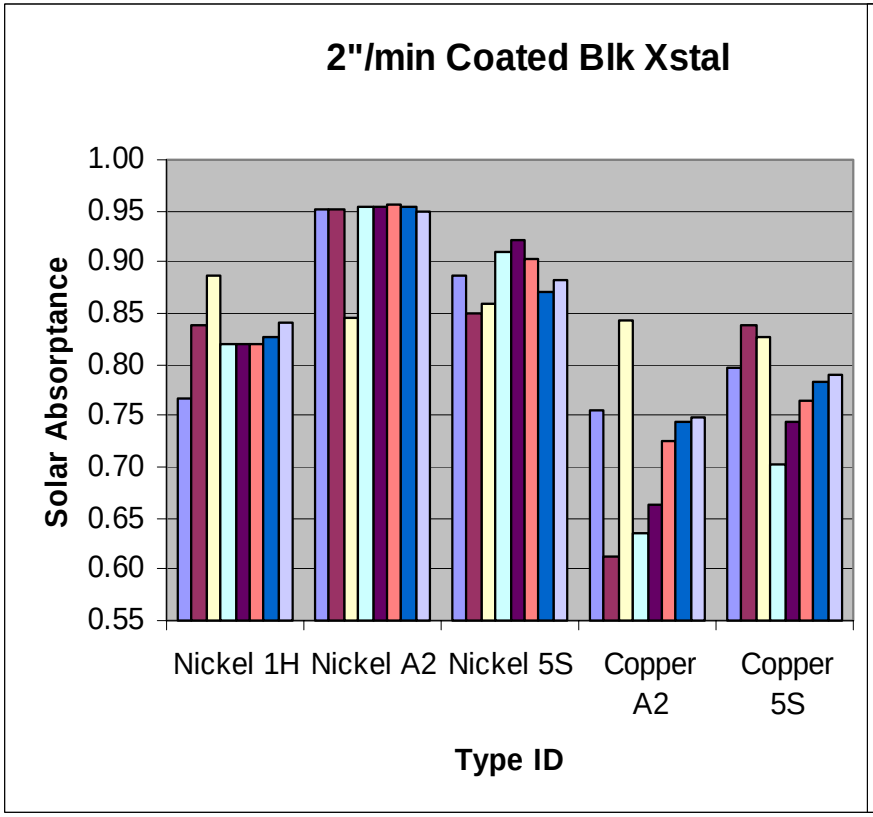
- **Prototype coating operation at Energy Laboratories, Inc. (ELI)**
- **Full length tubing (4 meters) process - spring 2001**
- **HCE cost <$250 each (non-evacuated, not installed, ...)**

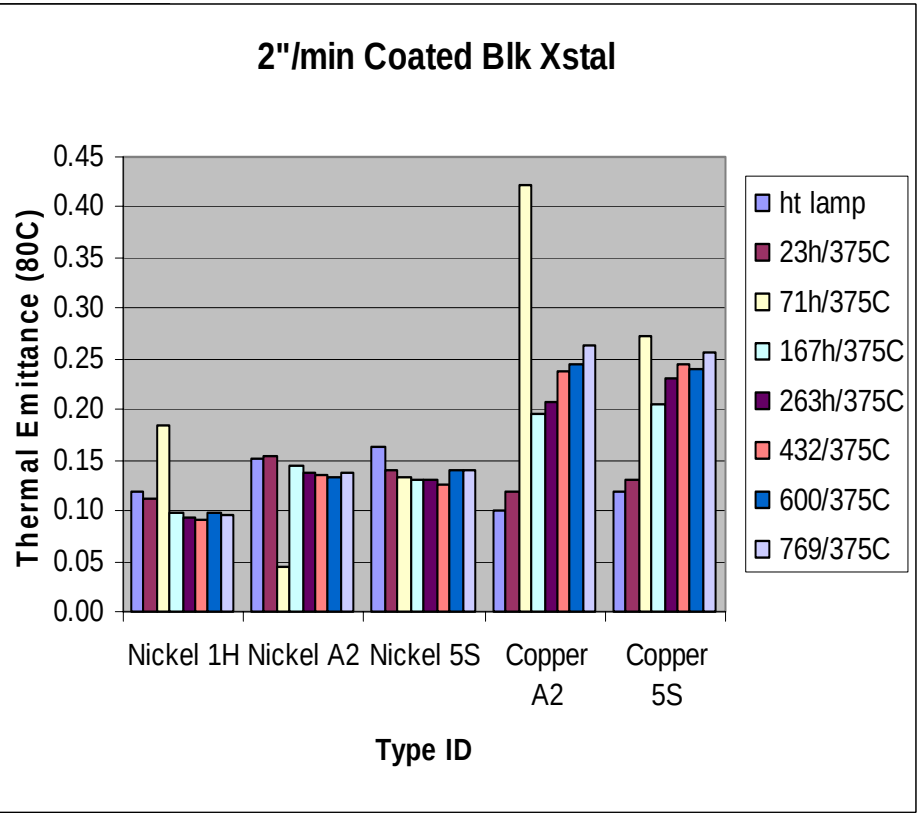
Black Crystal Solar Selective Absorber

CRADA Amendment with ELI - Feb 2000

- Black Crystal to higher temps
  - stainless steel substrate
  - surface preparation critical
  - good in-air thermal stability to 375C ...
- Process scale-up to full length tubing
- Prototype tubing ready for field install early FY01

Black Crystal Solar Selective Absorber





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Laboratory Samples ...

HCE Thermal Transfer Code

1-D code developed 1994 (Mancini, Sloan, Kearney)

Steady State Heat Loss and Gain - HCE

Converting to Visual Basic / Excel

- **more user friendly**
- **adding features and options**
  - **additional fluids (molten salts)**
  - **glass envelope (coatings, heat mirror)**
- **plotting**

Beta version - under evaluation

Summary

Heat Collector Element (HCE) - Selective Absorbers

- HCE Failure Data at SEGS VI & VII
- Purchase and Test new Solel UVAC Receiver
  install early FY01
- Apply protective (oxidation) coating over cermet
  prototype - autumn 2000
- Black Crystal on tubing prototypes - early FY01
- Modernized HCE Heat Transfer Code
  release Aug 2000